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(54) Title: HYALURONIC ACID FROM BACTERIAL CULTURE

(57) Abstract

Hyaluronic acid, a polysaccharide, is prepared in high yield from streptococcus bacteria by fermenting the bacteria under anaerobic conditions in a CO_2-enriched growth medium, separating the bacteria from the resulting broth and isolating the hyaluronic acid from the remaining constituent of the broth. The bacteria may be grown free of endotoxins by filtering all ingredients through a 10K Millipore (Reg. Trademark) filter prior to inoculation of the medium and subsequently maintaining pyrogen-free conditions. Separation of the microorganisms from the polysaccharide is facilitated by killing the bacteira with trichloroacetic acid. After removal of the bacterial cells and concentration of the higher molecular weight fermentation products, the hyaluronic acid is isolated and purified by precipitation, resuspension and reprecipitation.

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HYALURONIC ACID FROM BACTERIAL CULTURE

I. DESCRIPTION

Background of the Invention

Hyaluronic acid is a mucoid polysaccharide of biological origin. The sodium salt, sodium hyaluronate, in buffered physiological saline solution, has found significant use as a vitreous replacement in optical surgery and in other medical applications. Some of these applications are described in U.S. Patents 4,141,973 and 4,328,803. For such medical purposes, a pyrogen-free, highly purified sodium hyaluronate having a molecular weight in excess of 750,000 has heretofore been used. A commercial product known as HEALON™, manufactured by Pharmacia, Inc., Piscataway, N.J., is a one-percent solution of sodium hyaluronate sold for such purposes. For example, dilute HEALON™ solution (0.1 - 0.2% sodium hyaluronate) has been reported to be useful as an eye drop for the treatment of patients with keratitis sicca syndrome.

Hyaluronic acid has also been used as an ingredient for in vitro culture of leprosy baccili and as a component for cosmetic formulations. Cosmetic formulations, which are described in U.S. Patent 4,303,676, include both a low molecular weight fraction (about 10 -50,000) and a higher molecular weight fraction (in excess of 1×10^6).

The sources of hyaluronic acid for all of the foregoing uses have been rooster combs, human umbilical cords or other vertebrate tissue. Extraction and purification of hyaluronic acid from such tissue is a relatively complex process which results in a very expensive product.

Hyaluronic acid can be produced by Group A and C strains of Streptococcus bacteria. One use reported for the bacterial product appears to be as a reagent for determination of anti-streptococcal hyaluronidase in human serum samples, Kjems and Lebech, Acta Path. microbiol

scand., Section B, 84: 162-164, (1976). In that paper, the authors describe a defined media for growing Group A streptococci and isolating hyaluronic acid, reporting a yield of 0.3 grams per liter of culture broth. However, hyaluronic acid produced by bacteria has not found substantial use because it is of a low molecular weight range.

Brief Description of the Invention

The present invention provides hyaluronic acid from bacterial sources of a preferred higher molecular weight range than is reported in the prior art as being obtained from bacterial sources. It also provides a method for producing hyaluronic acid from bacterial sources in much higher yields than has previously been reported. The method additionally produces hyaluronic acid which has a purity comparable to or better than any presently available for medical applications. Although the hyaluronic acid produced by the present method typically has an average molecular weight of about 55,000, it has potentially significant use as an eye drop ingredient and as an ingredient of cosmetic formulations. The high yield, high purity and low cost of the hyaluronic acid produced by the inventive method also permits it to be used in ways not previously described or contemplated for hyaluronic acid obtained from mammalian or low yield bacterial sources. For instance, hyaluronic acid might be used in food preparations as a humectant, in other applications as a lubricant, and in post-surgical applications for reducing complications due to fibrotic response and/or adhesion formation. The material might also be used in tertiary oil recovery as a substitute for polyacrylamide, similar synthetic polymers or biologically-produced polymers.

The inventive method in its preferred form comprises growing a culture of a hyaluronic acid-producing streptococcus strain under anaerobic conditions in a CO_2-enriched growth medium, which includes those raw materials

necessary for the production of the hyaluronic acid by the bacteria, preferably although not necessarily killing the bacteria, separating the bacteria from the growth medium and isolating the hyaluronic acid. Preferably, growth is accomplished by fermentation in a broth culture. Other growth techniques and media may be used. For example, an agar culture may be used. Hence, the term "growth medium" herein is to be taken broadly as meaning liquid or solid media or combinations thereof and other types of growth in addition to fermentation, as are all well known in the art.

Although the preferred form of the invention contemplates the growth of bacteria directly in the culture medium in which the hyaluronic acid is to be produced, it is also possible to grow the bacteria in other growth media, separate the bacteria from the medium, resuspend the bacteria in a buffered suspension medium or distilled water and add the appropriate raw materials to the suspension for the production of the hyaluronic acid by the already grown bacteria. This is considered to be an art equivalent to the preferred method and merely involves the use of a resting cell suspension. Consequently, such terminology herein as "growing a culture" and the like is to be taken as includig both approaches within its purview.

Unlike prior methods of hyaluronic acid production, endotoxins can be excluded from the system initially by filtering all ingredients through a 10,000 (10K) nominal molecular weight limit (NMWL) cutoff filter, such as the Millipore® Pellicon® cassette tangential flow filtration system, prior to inoculation and subsequently maintaining pyrogen-free anaerobic growth conditions.

Detailed Description of the Invention

In the preferred embodiment of the present invention, a semi-defined growth medium such as the following is used:

1.	Casein hydrolysate, enzymatic	20.0 g
2.	Potassium chloride	3.0 g

3.	Sodium phosphate, dibasic	2.8 g
4.	Magnesium sulfate ($7H_2O$)	0.5 g
5.	Calcium chloride ($2H_2O$)	10.0 mg
6.	Glucose	20.0 g
7.	Vitamin solutions:	
	a) d-Biotin	1.0 mg
	b) D-Calcium Pantothenate	1.0 mg
	c) Choline chloride	1.0 mg
	d) Folic acid	1.0 mg
	e) i-Inositol	2.0 mg
	f) Nicotinamide	1.0 mg
	g) Pyridoxal HCl	1.0 mg
	h) Riboflavin	0.1 mg
	i) Thiamine HCl	1.0 mg

The medium is made up to one liter with reverse osmosis pyrogen-free water. Of course, other growth media suitable for this purpose may also be used.

A 100 ml culture of Streptococcus pyogenes type 18 is grown anaerobically for six hours in the medium at 37 ± 1°C. The other hyaluronic acid-producing bacteria referred to hereinabove may be used, but the type 18 is preferred. Five liters of the same medium are inoculated with this six-hour culture and grown to a high visible density, preferably to at least 2×10^8 cells per ml and typically to 5×10^8 cells per ml. The five liter inoculum is then used to inoculate 160 liters of medium in a 200 liter fermentor to begin a production run.

During the production run, the culture is grown with continuous agitation while infusing CO_2 gas at a rate of flow sufficient to maintain a dissolved level of CO_2 as determined by a CO_2 monitoring probe. A 5-10% level of dissolved CO_2 is preferred. The gas is preferably infused as an N_2/CO_2 mixture. An 85/15 ratio is preferred, but not critical. The gas is filter-sterilized as it is introduced into the growth chamber. Temperature is preferably controlled at about 37 ± 1°C. The pH is preferably

controlled to a substantially constant value ± 0.1 within the range of about 6.5 to 7.5 by monitoring with a pH probe/controller and by the addition of KOH as called for by the controller. Fermentation is considered complete when the pH of the culture stops dropping (no more KOH is called for to maintain pH within the set limitation), or when the cell density reaches the high visible density, typically 1-5 x 10^9 cells per ml. At this point the fermentation is terminated by the addition of 100% saturated solution of aqueous trichloroacetic acid to make the fermentation mixture up to a final trichloroacetic acid concentration of about 5%. This may vary.

The addition of trichloroacetic acid to the fermentation broth not only terminates growth by killing the bacteria, but also makes separation of the cells from the broth substantially easier by contributing to flocculation of the cells. The mixture without trichloroacetic acid is very difficult to separate without causing severe disruption of the integrity of both components. Microorganisms and the polysaccharide ie., the hyaluronic acid, do not readily separate by centrifugation or filtration without the trichloroacetic acid addition. Thus, while it is possible to terminate growth of the culture by other means, for instance heat treatment, trichloroacetic acid treatment has the advantage of facilitating subsequent separation of the hyaluronic acid.

The fermentation mixture is pumped from the fermenter through a 0.22 micrometer pore-size Durapore® filtration cassette using the aforementioned Millipore® tangential flow filtration system. This step concentrates the cells from 160 liters to approximately five liters. The filtrate is retained and diafiltered against greater than 10 mega-ohm conductivity reverse osmosis water using a 30,000 nominal molecular weight cut-off Millipore® Pellicon® cassette system until the filtrate, which is continuously discarded, reaches a conductivity of

approximately 0.5 mega-ohms. Diafiltering is a powered dialysis technique, such as is disclosed in Catalog Number OM029, March 1981, entitled Pellicon® Cassette System, of Millipore Corporation, Bedford, Massachusetts 01730, as opposed to conventional passive dialysis techniques. The hyaluronic acid is then concentrated by continuing the filtration process without further input of water.

The concentrate is then treated with reagent grade ethanol, preferably in a 3:1 ratio. Other alcohols, acetone, chloroform or other organic solvents as well as certain organic salts such as CETAB, a mixed trimethylammonium bromide, may be used to precipitate the hyaluronic acid or sodium hyaluronate from the aqueous solution. This should be done without any mixing other than occurs in the act of pumping the hyaluronic acid into the solvent. Stirring during alcohol treatment has been found to reduce the process yield of hyaluronic acid. The precipitate at this stage can be stored indefinitely in the dark at 4°C.

As is seen from the procedure described, a unique approach is found in the isolation of the hyaluronic acid from the broth by a two-step process in which a molecular weight separation step is carried out by diafiltration to separate the acid from substantially all of the lower molecular weight components of the broth, and then the acid is separated from any remaining broth constituents by precipitation.

The precipitated hyaluronic acid can be dewatered (removal of the bulk of the water/alcohol solution) by a number of conventional techniques and then resuspended in reverse osmosis water or a 0.15M NaCl solution. The resuspended material is then lyophilized (freeze-dried), spray-dried, vacuum-dried or diafiltered to remove the last traces of alcohol. Further purification is performed by making a 0.05M Borate buffer solution, pH 8.0, with approximately a 10 mg/ml sodium hyaluronate concentration.

0.32% CETAB, is then added to the solution and the mixture stirred at 4°C overnight to yield a precipitate, sodium hyaluronate. Other precipitating agents may be used, such as cetyl pyridium chloride or related salts. The precipitate is recovered by coarse filtration and resuspended in a 1M NaCl solution made with reverse osmosis water. The resuspended hyaluronic acid is then diafiltered and concentrated as above. The resultant hyaluronic acid can then be filter-sterilized and used or converted to sodium hyaluronate and then be filter-sterilized and used.

Conventional dewatering techniques include pressing, centrifugation, chemical addition and the like. The particular technique selected will depend on the subsequent intended use of the precipitate.

If a medical grade pyrogen-free product is desired, a pyrogen-free filtered growth medium is used and all operations of the process, including the isolation and processing of the hyaluronic acid/sodium hyaluronate are performed under conditions of a class 100 clean room using pyrogen-free containers. If the material is to be used only for chemical grade application, the cleanliness of the room and collection containers is not critical with respect to pyrogens.

The inventive method which emphasizes growing cells under non-aerated conditions prevents the streptococcus from producing its normal complement of end products, primarily the pyrogenic exotoxins for which the microbe is so well known. The described growth conditions also give a much higher yield of hyaluronic acid than has been previously reported. A minimum of 5 grams of hyaluronic acid per liter of culture broth has been obtained using the preferred cell growth and isolation conditions described above. The high yield under the non-aerated conditions is unexpected since one of the proposed functions of hyaluronic acid is thought to be that of providing an oxygen barrier for the cell. Thus, its

production would only be expected to be maximized under conditions of exposure to oxygen.

The hyaluronic acid/sodium hyaluronate prepared as described has an average molecular weight of about 55,000 ± about 20% within a molecular weight range of from about 10,000 -2,000,000 as determined by gel filtration or by quasi-elastic light scattering techniques. These techniques are well known as are the variations in measurement and the results obtained with them due to biological variation. The product also has a protein content of between 0.3% and 0.03% depending on method of analysis. The UV absorption of the 1% solution is 0.314 at 260 nm and 0.169 at 280 nm. Viscosity of a 1% solution is approximately 300 centistokes.

A 0.5-1.5 percent solution of the pyrogen-free NaHy produced by the inventive method may be used as an eye drop composition in place of the very dilute solutions of high molecular weight rooster comb derived hyaluronic acid presently used for treatment of keratitis sicca.

Other hyaluronic acid-producing streptococci in the Group A and Group C strains may be used in the invention. Additionally, variations in the growth medium and conditions of growth, as well as variations in the isolation procedures, may be made without departing from the invention which is set forth in the following claims.

II. WHAT IS CLAIMED IS:

1. A method of producing hyaluronic acid comprising:

fermenting a broth culture of hyaluronic acid-producing streptococcus bacteria in a growth medium under CO_2-enriched anaerobic conditions;

separating the bacterial cells from the resulting broth; and

isolating the hyaluronic acid from the remaining constituents of the broth.

2. A method as in claim 1 wherein the growth medium is made pyrogen-free prior to inoculation by filtration thereof through a 10,000 molecular weight cutoff filter.

3. A method as in claim 1 wherein the bacterial cell separation step includes first adding trichloroacetic acid to the broth.

4. A method as in claim 3 wherein the trichloroacetic acid is added to make the fermentation mixture up to a final concentration of 5-6%.

5. A method as in claim 3 wherein the growth of the bacteria is terminated by said addition of trichloroacetic acid.

6. A method as in claim 1 wherein isolation is accomplished by separating the acid and those broth constituents of similar or higher molecular weight and then separating the acid from those similar broth constituents by precipitation.

7. The method of claim 6 wherein the precipitation is accomplished by adding the hyaluronic acid and the

remaining broth constituents to ethanol without substantial mixing.

8. The method of claim 1 wherein isolation is accomplished by separating the broth from the cells, diafiltering the broth and precipitating the acid from solution by adding the solution to an organic solvent without substantial mixing.

9. A method as in claim 1 wherein the fermentation step includes controlling the pH at a substantially constant value $\pm$ 0.1 within the range of 6.5 - 7.5 and the temperature to 37 $\pm$ 1°C throughout fermentation.

10. A method as in claim 9 wherein the pH is controlled by the automatic addition of base with a pH probe/controller.

11. A method as in claim 1 wherein the dissolved CO_2 is maintained at a concentration of about 5-10%.

12. A method as in claim 1 wherein the bacteria is grown to a density of greater than 2×10^8 cells per ml before termination of growth.

13. The method of claim 1 wherein the baceria are Streptococcus pyogenes type 18.

14. A method as in claim 6 filtering the growth medium through a 10,000 molecular weight cutoff filter prior to inoculation with the bacteria culture and performing the remaining steps under conditions of a class 100 clean room using pyrogen free containers.

15. A method as in claim 14 further comprising: refining the isolated hyaluronic acid by dissolution

thereof in a mildly basic buffered solution, precipitation of sodium hyaluronate with a mixed alkyl trimethylammonium bromide, resuspending the precipitate in dilute sodium chloride solution and reprecipitating it as acid by adding it to ethanol without stirring.

16. Hyaluronic acid of a molecular weight fraction ranging from about 10,000 to about 2,000,000 daltons with an average molecular weight of about 55,000 daltons ± about 20% produced by:

fermenting a broth culture of hyaluronic acid-producing streptococcus bacteria under anaerobic conditions in a CO_2-enriched growth medium;

separating the bacterial cells from the resulting broth; and

isolating the hyaluronic acid from the remaining constituents of the broth.

17. The acid of claim 16 wherein the bacteria are Streptococcus pyogenes type 18.

18. The acid of claim 16 wherein isolation is accomplished by separating the acid and those broth constituents of similar or higher molecular weight and then separating the acid from those similar broth constituents by precipitation.

19. The acid of claim 17, wherein the precipitation is accomplished by adding the hyaluronic acid and the remaining broth constituents to ethanol without any substantial mixing.

20. The acid of claim 16, wherein isolation is accomplished by separating the broth from the cells, diafiltering the broth and precipitating the acid from solution by adding the solution to an organic solvent without any substantial mixing.

21. The acid of claim 16 wherein the protein content ranges between about 0.3% and 0.03%, the UV absorption of a 1% solution is 0.314 at 260 nm and 0.169 at 280 nm and the viscosity is about 300 centistokes.

22. The acid of claim 21, wherein isolation is accomplished by separating the acid and those broth constituents of similar or higher molecular weight and then separating the acid from those similar broth constituents by precipitation.

23. The acid of claim 22, wherein the precipitation is accomplished by adding the acid and the remaining broth constituents to ethanol without substantial mixing.

24. The acid of claim 21, wherein isolation is accomplished by separating the broth from the cells, diafiltering the broth and precipitating the acid from solution by adding the solution to an organic solvent without substantial mixing.

25. In the method of producing hyaluronic acid involving production of same by bacteria, the improvement comprising isolating the acid from the broth in which the bacteria grows by separating the acid and those broth constituents of similar or higher molecular weight from the liquid and then separating the acid from those similar broth constituents by precipitation.

26. The method of claim 25 wherein the bacteria are Streptococcus pyogenes type 18.

27. The method of claim 25 wherein the precipitation is accomplished by adding the acid and the remaining broth constituents to ethanol without substantial mixing.

28. The method of claim 25 wherein isolation is accomplished by separating the broth from the bacteria, diafiltering the broth and precipitating the acid from resulting solution by adding the solution to an organic solvent without any substantial mixing.

29. In the method of producing hyaluronic acid involving production of same by bacteria, the improvement involving the maintenance of CO_2-enriched anerobic conditions in the environment of the bacteria growth medium.

30. A method of producing hyaluronic acid comprising:

growing a culture of hyaluronic acid-producing streptococcus bacteria in a growth medium under CO_2-enriched anaerobic conditions;

forming a liquid suspension of the bacteria and its by-products in the case where the formation of such a suspension is not inherent in the growth method being used;

separating the bacterial cells from the suspension; and

isolating the hyaluronic acid from the constituents of the remaining liquid.

31. A method as in claim 30 wherein isolation is accomplished by separating the acid and those liquid constituents of similar or higher molecular weight from the liquid and then separating the acid from those similar constituents.

32. A method as in claim 30 wherein the growth step includes controlling the pH at a substantially constant $\pm$ 0.1 value within the range of 6.5 - 7.5 and the temperature to 37 $\pm$ 1°C throughout fermentation.

33. A method as in claim 30 wherein the pH is controlled by the automatic addition of base with a pH probe/controller.

34. Hyaluronic acid of a molecular weight fraction ranging from about 10,000 to about 2,000,000 with an average molecular weight of about 55,000 ± about 20% produced by:

growing a culture of a hyaluronic acid-producing streptococcus bacteria under CO_2-enriched anaerobic conditions;

forming a liquid suspension of the bacteria and its by-products in the case where the formation of such a suspension is not inherent in the growth method being used;

separating the bacterial cells from the suspension; and

isolating the hyaluronic acid from the constituents of the remaining liquid.

35. The acid of claim 34, wherein isolation is accomplished by separating the acid and those constituents of similar or higher molecular weight from the liquid and then separating the acid from those similar constituents.

36. The acid of claim 35, wherein the last separation is by precipitation which is accomplished by adding the acid and the remaining constituents to ethanol without substantial mixing.

37. The acid of claim 34 wherein the protein content ranges between about 0.3% and 0.03%, the UV absorption of a 1% solution is 0.314 at 260 nm and 0.169 at 280 nm and the viscosity is about 300 centistokes.

38. The acid of claim 37, wherein isolation is accomplished by separating the acid and those constituents

of similar or higher molecular weight from the liquid and then separating the acid from those similar constituents.

39. The acid of claim 38 wherein the last separation is by precipitation which is accomplished by adding the acid and the remaining constituents to ethanol without substantial mixing.

40. A method of producing hyaluronic acid comprising:

growing a culture of acid-producing streptococcus bacteria under CO_2-enriched anaerobic conditions on a solid growth medium;

forming a liquid suspension of the bacteria and its by-products to separate same from the solid medium;

separating the bacterial cells from the suspension; and

isolating the hyaluronic acid from the constituents of the remaining liquid.

41. A method as in claim 40 wherein isolation is accomplished by separating the acid and those liquid constituents of similar or higher molecular weight from the liquid and then separating the acid from those similar constituents.

42. The method of claim 41 wherein the last separation is by precipitation which is accomplished by adding the hyaluronic acid and the remaining constituents to ethanol without substantial mixing.

43. A method as in claim 40 wherein the fermentation step includes controlling the pH at a substantially constant value $\pm$ 0.1 within the range of 6.5 - 7.5 and the temperature to 37 $\pm$ 1°C throughout fermentation.

44. A method as in claim 40 wherein the dissolved CO_2 is maintained at a concentration of about 5-10%.

45. A method as in claim 40 wherein the bacteria is grown to a density of greater than 2×10^8 cells per ml before termination of growth.

46. A method as in claim 40 further comprising: refining the isolated hyaluronic acid by dissolution thereof in a mildly buffered solution, precipitation of sodium haluronate with a mixed alkyl trimethylammonium bromide, resuspending the precipitate in dilute sodium chloride solution and reprecipitating it as acid by adding it to ethanol without stirring.

47. A method of producing hyaluronic acid comprising:

providing hyaluronic acid-producing bacteria;

combining the bacteria with a growth medium whereby the bacteria produces by-products including hyaluronic acid;

maintaining CO_2-enriched anerobic conditions in the environment of the growth medium;

forming a liquid suspension of the bacteria and its by-products in the case where the formation of such a suspension is not inherent in the growth method and medium being used;

separating the bacteria from the suspension;

isolating the hyaluronic acid from the constitutents of the remaining liquid.

48. The method of claim 47 wherein the bacteria is initially provided in a resting suspension.

49. The method of claim 47 wherein the bacteria is Streptococcus pyogenes type 18.

INTERNATIONAL SEARCH REPORT

International Application No PCT/US83/01428

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

INT. CL.[3] C12P 19/04 C07H 1/00, 5/04; C07G 17/00

U.S. CL. 435/101; 536/55.1,123

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	435/101,801,803 536/55.1,123

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
A	U.S., A, 4,141,973, PUBLISHED 27 FEBRUARY 1979, BALAZS.	1-49
X	U.S., A, 4,303,676, PUBLISHED 01 DECEMBER 1981, BALAZS.	16,24 and 34-39
A	U.S., A, 2,975,104, PUBLISHED 14 MARCH 1961, WARREN.	1-49
Y	"THE BIOSYNTHESIS OF HYALURONATE BY GROUP A STREPTOCOCCI", YAEL GINTZBURG, A 1955 DOCTORAL THESIS AT THE UNIVERSITY OF MINNESOTA, 115 PAGES.	1-49
Y	N, CARBOHYDRATES OF LIVING TISSUE, ISSUED 1962, M. STACEY ET AL, CHAPTER 2-"HYALURONIC ACID", PAGES 37-58.	16-28 and 34-39
X	N, CHEM & MOL. BIOL. OF THE INTERCELLULAR MATRIX 2, E.A. BALAZS (1970), "STRUCTURE OF HYALURONIC ACID," BY T.C. LAURENT, PP. 703-732.	16-24 and 34-39
Y	N, THE JOURNAL OF BIOLOGICAL CHEMISTY , VOL. 254, NO. 14, ISSUED JULY 25, 1979, BALTIMORE, MARYLAND, U.S.A., SUGAHARA ET AL, "BIOSYNTHESIS OF HYALURONIC ACID BY STREPTOCOCCUS,", PAGES 6252-6261.	16-28 and 34-39

* Special categories of cited documents: [15]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
13 DECEMBER 1983	21DEC 1983
International Searching Authority [1]	**Signature of Authorized Officer** [20]
ISA/US	LIONEL M. SHAPIRO

Form PCT/ISA/210 (second sheet) (October 1981)

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, ** with indication, where appropriate, of the relevant passages **	Relevant to Claim No **
A	N, JOURNAL OF CLINICAL MICROBIOLOGY, ISSUED DECEMBER 1980, "COMPARISON OF MEDIA AND CULTURE TECHNIQUES FOR DETECTION OF STREPTOCOCCUS PNEUMONIAE IN RESPIRATORY SECRETIONS," BY T.C. WU ET AL, PAGES 772-775.	1-24 and 29-49
Y	N, JOURNAL OF BACTERIOLOGY, ISSUED DECEMBER 1979, "HYALURONIC ACID CAPSULE: STRATEGY FOR OXYGEN RESISTANCE IN GROUP A STREPTOCOCCI, BY P. PATRICK CLEARY, PP. 1090-1097.	1-24 and 29-49
Y	N, JOURNAL OF BACTERIOLOGY, VOL. 117, NO. 2, ISSUED FEBRUARY 1974, "CARBON DIOXIDE CONTROL OF LAG PERIOD AND GROWTH OF STREPTOCOCCUS SANGUIS," BY ROY REPASKE ET AL, PAGES 652-659.	1-24 and 29-49
Y	N, INFECTION AND IMMUNITY, VOL. 27 NO. 2, ISSUED FEBRUARY 1980, "GROWTH CHARACTERISTICS OF GROUP A STREPTOCOCCI IN A NEW CHEMICALLY DEFINED MEDIUM", BY I. VAN DE RIJN ET AL, PAGES 444-448.	1-24 and 29-49